contained in the carbon fiber, and discharging to outside of a heat treatment furnace the impurity through a vicinity of a highest temperature section of the furnace while being accompanied by a carrier gas, wherein the obtained carbon fiber comprises about 30 ppm or more to about 100 ppm or less of a metal element selected from the group consisting of Fe, Ni or Co.

Applicants set forth the following Table that summarizes a comparison of the carbon fiber of the present invention, as exemplified by Example 1 of the present application, with the carbon fiber of Comparative Example 1 of the present specification and the disclosures of Tennent et al, Colomer and Lambert et al that have been cited by the Examiner.

Comparison of Present Invention with References

Table 1: Comparison of Carbon Fiber

Claim 13: A graphitized carbon fiber	Example 1	Comparative Example 1	Tennent	Colomer	Lambert
graphitized	O	O	O	×	×
discharging the impurity through a vicinity of highest-temperature section of the furnace while being accompanied by a carrier gas	O	×	×	×	×
the content of Fe, Ni or Co being 30 to 100 ppm	O	×	?	×	×

(Note) O: agree ×: disagree ?: unknown

Claims 13 and 15 to 17 have been rejected under 35 U.S.C. § 103(a) as obvious over Tennent et al in view of the Lambert et al publication.

Applicants submit that Tennent et al and Lambert et al do not disclose or render obvious the presently claimed invention and, accordingly, request withdrawal of this rejection.

Tennent et al do not set forth any details on the method of the heat treatment. Tennent et al do disclose that a metal catalyst particle is employed. Therefore, since Tennent et al disclose a metal catalyst, applicants submit that it would be expected that the fiber filament disclosed at column 2 would contain metal impurity, and that since Tennent et al do not disclose the specific heat treatment set forth in the present claims, the fiber filaments described in Tennent et al would be expected to have a metal content of more than 100 ppm, such as illustrated in the Comparative Example of the present specification.

The Examiner recognizes that Tennent et al do not specifically teach a metal catalyst impurity content between 30 and 100 ppm, but relies on Lambert et al for teaching a process in which "most of the catalyst" was removed by a heat-treatment.

The Examiner argues that it would have been obvious to apply the Lambert et al treatment to the fibers of Tennent et al in order to obtain a purified product.

The Examiner has asserted that it "is expected that the resulting product will have remaining catalyst metal impurities in an amount 30 and 100 ppm because no difference is seen between the process of Lambert et al and that of the instantly claimed invention". The Examiner states that the Lambert et al method comprises heating the samples under vacuum at high temperatures, for example, 1600°C.

In response, Lambert et al disclose that carbon nanotubes can be produced either as multi-shell nanotubes (also known as "multiwalled nanotubes" or MWNT") or as single-shell nanotubes (also known as "single-walled nanotubes" or "SWNT"). Lambert et al disclose that single-shell nanotubes are produced by using an electric arc-discharge process that employs a

metallic catalyst. The Lambert et al publication is particularly directed to a process for producing high purity single shell nanotubes by eliminating the remaining catalyst particles in the final product, as disclosed at page 364, second column.

Thus, in Lambert et al, the carbon nanotube was produced by carbon sublimation by an electric arc-discharge process. As disclosed in Lambert et al, a carbon nanotube produced by an arc process is a single walled nanotube (SWNT). This SWNT differs from a graphite structure such as obtained in the present invention.

A graphite structure of the present invention is a laminate structure of graphen sheets. The SWNT of Lambert et al, however, consists of one graphen sheet layer, and does not satisfy the definition of a graphite structure.

The studies by Lambert et al employed an arc process. In the arc process, the temperature of the reaction field is high as compared with a thermal decomposition method, which is the method recited in the present claims. The thermal decomposition method produces vapor grow carbon fiber (VGCF) that has a multiwalled structure. In the case of MWNT, its graphite structure is readily grown and a clear image is observed through a transmission electron microscope (TEM).

The production process of VGCF by a "thermal decomposition method" as in the present claims is a process of obtaining VGCF by "thermally decomposing" hydrocarbon, which is a carbon source of MWNT. On the other hand, the production method of SWNT in Lambert et al is an "arc process" of obtaining carbon nanotubes (CNT) by sublimating carbon. Thus, the production method of SWNT in Lambert et al is not a thermal decomposition method. The

treatment of impurities obtained by the Lambert et al electric arc-discharge method is excluded in the present invention.

Further, in Section 3.3, beginning at page 366, Lambert et al describe their attempts to purify nanotubes by vacuum annealing at high temperature. In Section 3.3, the carbon nanotubes were made by use of a cobalt catalyst.

In Section 3.3, at page 366, right-hand column, Lambert et al state:

> Fig. 3a shows a portion of the sample annealed for one day, revealing that most of the cobalt has been removed from the sample. Apparently, carbon nanotubes are not modified by this heat-treatment, i.e. they are not opened. There is still some carbon soot in the sample and some modified carbon structure have appeared. First, we can see numerous graphite shells that are left behind in samples after the catalyst particles have disappeared. It seems that the remaining cobalt particles have been trapped in these graphite shells. For a short annealing time (Fig. 3b), these new carbon shells are quickly formed with most of them containing small cobalt particles. (Emphasis added).

In the Discussion of Section 4, at page 370, right-hand column, Lambert et al state that:

> ...the catalyst particles could not be completely removed (traces remained as seen from Figs. 3a and 3b) even after a few days of annealing and this could mean that the catalyst has reacted to form a carbonaceous species with a high vapor pressure such as, for example, metal carbides. In the best case, the most efficient purification method leads to more than 90% of the catalyst particles being removed. (Emphasis added).

Since Lambert et al state that the most efficient purification method leads to more than 90% of the catalyst particles being removed, applicants submit that about 10% of the catalyst particles would remain. Applying this 10% figure to the 2% mass of catalyst particles employed in Example 1 of the present application, one would expect that there would be 2000 ppm of catalyst particles that would remain if the Lambert et al treatment were applied to Example 1, which is far removed from the 30-100 pmm of the present claims.

Further, applicants submit that one of ordinary skill in the art would not be led to employing the Lambert et al method with the vapor grown particles of Tennent et al.

The methods of Tennent et al and the present invention all are a thermal decomposition method and the production conditions differ from those of Lambert et al. The method for forming a SWNT in Lambert et al is a carbon sublimation method and cannot be characterized as being a method for forming a vapor grown carbon fiber by a thermal decomposition method.

Applicants submit that one of ordinary skill in the art would not be led to combining the teachings of Tennent et al with Lambert et al with Lambert et al because Tennent et al relate to multiwalled carbon nanotubes (MWNT), whereas the teachings of Lambert et al relating to removal of catalyst particles are directed to single wall carbon nanotubes (SWNT).

In addition, the reduction in the amount of catalyst particles disclosed in Lambert et al occurs in SWNT, which is formed by a different process than the thermal decomposition method disclosed in Tennent et al. There is no disclosure or suggestion in Lambert et al that a similar reduction in the amount of catalyst particles could be achieved in a MWNT formed by a thermal decomposition.

Further, although the Examiner states that he sees no difference between the process of Lambert et al and that of the presently claimed invention, Lambert et al do not disclose a high temperature heat treatment in which a carrier gas is discharged from the highest temperature section of the furnace. In addition, Lambert et al do not disclose the temperature recited in claim 15.

In the Office Action, the Examiner states that while it is true that Lambert et al apply the treatment to a sample of single-walled nanotubes, "it would be wrong to assume that Lambert teaches its use for the purification of single-walled nanotubes only".

The Examiner argues that the removal of catalyst impurities from all nanotubes, multi-walled as well as single-walled, would have been envisioned by one of ordinary skill in the art because this is a problem that most nanotube samples have. The Examiner argues, therefore, that it would have been obvious to apply the treatment of Lambert et al to a sample of multi-walled carbon nanotubes, such as those in Tennent et al. The Examiner also states that single-walled nanotubes are vapor grown fibers, and their method of production does not limit the fibers themselves.

Although the Examiner states that it would be wrong to assume that Lambert et al teach the treatment method disclosed therein only for the purification of single-walled nanotubes, applicants point out that the Examiner has not pointed to any evidence as to why one of ordinary skill in the art would assume that this method could be applied to double-walled or multi-walled nanotubes.

The fact is that Lambert et al were well aware of the existence of multi-walled tubes and recognized that multi-walled tubes and single-walled tubes have different properties. At page 370, left-hand column, Lambert et al disclose that they tried to purify single-walled tubes by using a method that had been used to purify multi-walled tubes. Lambert et al state that this method was not successful when applied to the single-walled tubes. Accordingly, applicants

submit that Lambert et al teach that it cannot be expected that a purification for one type of tube would be successful with any other type of tube.

Applicants submit that there is no teaching or suggestion that one of ordinary skill in the art would have been led to the use of the Lambert et al method for multi-walled nanotubes.

In addition, the Examiner states that applicants have argued that the process of Lambert et al would not be suitable to achieve the claimed metal content. The Examiner states that such an argument is based solely on the assumption of using one example and faulty computations.

The Examiner states that Lambert et al teach the removal of greater than 90% of the metal impurities, not specifically 90%.

The Examiner further states that various VGCF samples may have different metal contents and, therefore, the assumption that the process of Lambert et al would be incapable of achieving the claimed metal content in applicants' Example does not justify the conclusion that the process is incapable of meeting the claimed range.

The Examiner states that "[u]nless it is shown that the process of Lambert et al is incapable of meeting the claimed range, it is expected that the process" of Lambert et al is capable of achieving the claimed range because the process "is almost identical" to the process employed by applicants.

In response, with respect to the Examiner's argument that applicants' argument is based solely on assumptions using one example and faulty computations, applicants point out that the only specific figure disclosed in Lambert et al is the "more than 90%" value. Thus, this is the only disclosure in Lambert et al upon which specific calculations can be made.

With respect to the Examiner's argument that Lambert et al do not teach 90% specifically, but teaches "more than 90%", applicants point out that Lambert et al state that this occurs in the best case and not in all cases.

Further, using the 2000 ppm of catalyst particles of Example 1 of the present specification, in order to arrive at 100 ppm, Lambert et al would have to remove 95% of the catalyst particles to arrive at the values shown in the present claims. While it is true that one of ordinary skill in the art reading Lambert et al might envision values higher than 90%, such as 91% or 92%, applicants submit there is absolutely no teaching or suggestion that, based on Lambert et al, one would expect that Lambert et al would be able to remove 95% of the catalyst particles. If Lambert et al had been able to achieve such a high rate of removal, he surely would have given this figure instead of the 90% value.

With respect to the Examiner's comment that various VGCF samples may have different metal contents and that one, therefore, cannot base the calculations on 2000 ppm of catalyst particles, applicants point out that Lambert et al do not contain any disclosure of the amount of catalyst particles that are in the single-walled nanotubes. The Examiner does not offer any indication what the catalyst content in Lambert et al would be. Applicants submit that it is pure speculation on the Examiner's part to assert that Lambert et al would be able to achieve the claimed metal content.

With respect to the Examiner's statement that "unless it is shown that the process of Lambert et al is incapable" of meeting the claimed range, it is expected that the process "is capable" of achieving the claimed range because "it is almost identical" to the process of

applicants, applicants submit that the Examiner has applied the wrong test for patentability. The burden is not on applicants to show that Lambert et al is incapable of meeting the claimed range. Rather, the burden is on the Examiner to show that there is reasonable expectation that Lambert et al would be able to satisfy the present claims. Moreover, the Examiner cannot rely on the fact that the Lambert et al process is "almost identical to the process of applicants" to satisfy this burden because the Examiner cannot use an applicants' disclosure against the applicants, but must find the teachings in the prior art.

In addition, it is not true that the Lambert et al process is almost identical to the process of applicants. As discussed above, applicants process is directed to a multi-walled nanotube, whereas the Lambert et al process is directed to a single-walled nanotube. There has been absolutely no teaching or suggestion that the Lambert et al process could be applied to a multi-walled nanotube, and there is absolutely no teaching or suggestion that the process can achieve a 100 ppm metal content.

Further, Lambert et al do not disclose a high temperature heat treatment in which a carrier gas is discharged from the highest temperature section of the furnace. Thus, there are clear differences between the process of Lambert et al and the process set forth in the present claims.

In view of the above, applicants submit that the combination of Tennent et al with Lambert et al would not have led one of ordinary skill in the art to the present invention and, accordingly, request withdrawal of this rejection.

Claims 13 and 15 to 17 have been rejected under 35 U.S.C. § 103(a) as obvious over Tennent et al taken with the newly cited Colomer et al publication.

Applicants submit that Tennent et al and Colomer et al do not disclose or render obvious the subject matter of claims 13 and 15 to 17 and, accordingly, request withdrawal of this rejection.

Applicants have discussed Tennent et al in detail above, and rely on that discussion.

In this rejection, the Examiner relies on the Colomer et al publication for a teaching of a method of removing catalyst material that remain in vapor grown carbon nanotubes.

The Colomer et al method comprises stirring a nanotube sample into a solution of hydrofluoric acid to dissolve the metal particle.

In Section 3.1, Colomer et al state that the separation of the nanotubes from the catalyst was carried out using hydrofluoric acid to dissolve the zeolitic support and the metal (catalyst) particles. This treatment was applied with stirring for 24 hours, followed by filtering and washing with distilled water. Colomer et al state that this allows the "total elimination of catalyst (confirmed by the disappearance of the characteristic X-ray peaks on the powder to fraction pattern spectra)."

In Colomer et al, Co supported as a catalyst on zeolite was reacted at 600°C by using acetylene as the carbon source, and zeolite and Co (catalyst) were dissolved in HF. Colomer et al state that since the corresponding peak disappeared as confirmed by powder X-ray diffraction, the catalyst was eliminated. However, the quantitative limit in the powder X-ray diffraction is approximately 0.5 wt% (5,000 ppm). Accordingly, even if the peak disappeared, this does not mean that the impurity content was from 30 to 100ppm.

Accordingly, applicants submit that the present invention can not be achieved by combining the graphitization of Tennent et al and the dissolution in HF of Colomer et al.

With respect to Colomer et al, the Examiner states that conclusive proof that all of the catalyst material is removed from the carbon samples is not required, and the Examiner is not relying on proof that all of the catalyst material would be removed. The Examiner states that the lack of conclusive proof of an occurrence does not mean that such is not true, and that he is maintaining his expectation that the occurrence would take place.

Applicants submit us that the Examiner has mischaracterized applicants' arguments. Applicants did not argue that conclusive proof must be shown that all of the catalyst material was removed in Colomer et al. Instead, applicants pointed out that Colomer et al disclose that the total elimination of catalyst was confirmed by the disappearance of the characteristic x-ray peaks. Applicants also stated that the quantitative limit in powder x-ray diffraction is approximately 5000 ppm. Applicants therefore argued that even if a peak disappeared, this does not mean that the impurity content was from 30 to 100 ppm, and that at most, what could be expected is that the impurity content would be less than 5000 ppm.

Applicants recognize that it is difficult to provide an exact quantitative limit or percentage for x-ray diffraction across the board, since it depends on the particular elements and samples, but in the case of x-ray diffraction, the quantitative limit generally would be 10,000 ppm to 1,000 ppm based on the ordered equipment. Thus, at best, what would be expected is that the impurity content would be less than 1,000 ppm. Applicants point out that the Examiner has provided absolutely no evidence on what the expected value would be, and has not provided

any basis for arriving at an expected value. Applicants do not see how the Examiner arrives at his conclusion that 30 to 100 ppm would be expected. Applicants submit that the Examiner is relying on hindsight.

In view of the above, applicants submit that Tennent et al and Colomer et al do not defeat the patentability of claims 13 and 15 to 17 and, accordingly, request withdrawal of this rejection.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

Sheldon I. Landsman

Sheldon I. Landsman
Registration No. 25,430

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

WASHINGTON OFFICE
23373
CUSTOMER NUMBER

Date: December 16, 2005